

We Claim

1. A mass spectrometer comprising:
- an ion source for producing ions;
  - an input vacuum chamber comprising at least one AC-only ion guide for transmitting said ions, said AC-only ion guide comprising a plurality of electrodes having apertures, said apertures being aligned so that ions travel through them as they are transmitted by said ion guide;
  - an analyzer vacuum chamber comprising an ion mass analyzer disposed to receive ions after they have been transmitted by said ion guide;
  - at least one differential pumping apertured electrode through which ions may pass, said at least one differential pumping apertured electrode being disposed between said input vacuum chamber and said analyzer vacuum chamber to permit said analyzer vacuum chamber to be maintained at a lower pressure than said input vacuum chamber;
  - at least one alternating current (AC) generator connected to an input chamber reference potential for providing AC potentials to said plurality of electrodes;
- wherein:
- at least 90% of said apertures are substantially the same size;
  - at least 90% of said plurality of electrodes forming said AC-only ion guide are connected to said AC generator in such a way that at any instant during an AC cycle of the output of said AC generator, adjacent ones of said electrodes are supplied respectively with approximately equal positive and negative potentials relative to said input chamber reference potential; and
- wherein said input vacuum chamber is arranged to be maintained at a pressure selected from the group consisting of: (i)  $\geq 0.1$  mbar; (ii)  $\geq 0.5$  mbar; (iii)  $\geq 0.7$  mbar; (iv)  $\geq 1.0$  mbar; (v)  $\geq 1.3$  mbar; (vi)  $\geq 1.5$  mbar; (viii)  $\geq 2.0$  mbar; (ix)  $\geq 2.5$  mbar; (x)  $\geq 3.0$  mbar; (xi)  $\geq 3.5$  mbar; (xii)  $\geq 4.0$  mbar; (xiii)  $\geq 4.5$  mbar; (xiv)  $\geq 5.0$  mbar; (xv)  $\geq 6.0$  mbar; (xvi)  $\geq 7.0$  mbar; (xvii)  $\geq 8.0$  mbar; (xviii)  $\geq 9.0$  mbar; (xix)  $\geq 10.0$  mbar; (xx) 1-5 mbar; (xxi) 1-2 mbar; (xxii) 0.5-1.5 mbar; (xxiii)  $\leq 20$  mbar; and (xxiv)  $\leq 30$  mbar.

2. A mass spectrometer as claimed in claim 1, wherein said electrodes comprise a plate having an aperture therein.

3. A mass spectrometer as claimed in claim 1, wherein said electrodes comprise a wire or rod bent to form a substantially closed ring.

4. A mass spectrometer as claimed in claim 1, wherein alternate ones of said electrodes are connected to each other and to one of the output connections of a single AC generator.

5. A mass spectrometer as claimed in claim 1, wherein the AC-only ion guide comprises at least 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, or 100 electrodes.

6. A mass spectrometer as claimed in claim 1, wherein said electrodes have internal diameters or dimensions selected from the group consisting of: (i)  $\leq 5.0$  mm; (ii)  $\leq 4.5$  mm; (iii)  $\leq 4.0$  mm; (iv)  $\leq 3.5$  mm; (v)  $\leq 3.0$  mm; (vi)  $\leq 2.5$  mm; (vii)  $3.0 \pm 0.5$  mm; (viii)  $\leq 10.0$  mm; (ix)  $\leq 9.0$  mm; (x)  $\leq 8.0$  mm; (xi)  $\leq 7.0$  mm; (xii)  $\leq 6.0$  mm; (xiii)  $5.0 \pm 0.5$  mm; and (xiv) 4-6 mm.

7. A mass spectrometer as claimed in claim 1, wherein the length of said AC-only ion guide is selected from the group consisting of: (i)  $\geq 100$  mm; (ii)  $\geq 120$  mm; (iii)  $\geq 150$  mm; (iv)  $130 \pm 10$  mm; (v) 100-150 mm; (vi)  $\leq 160$  mm; (vii)  $\leq 180$  mm; (viii)  $\leq 200$  mm; (ix) 130-150 mm; (x) 120-180 mm; (xi) 120-140 mm; (xii)  $130 \text{ mm} \pm 5, 10, 15, 20, 25 \text{ or } 30 \text{ mm}$ ; (xiii) 50-300 mm; (xiv) 150-300 mm; (xv)  $\geq 50$  mm; (xvi) 50-100 mm; (xvii) 60-90 mm; (xviii)  $\geq 75$  mm; (xix) 50-75 mm; (xx) 75-100 mm; (xxi) 150-200 mm; (xxii)  $\geq 200$  mm; and (xxiii) 50-200 mm.

8. A mass spectrometer as claimed in claim 1, further comprising:  
an intermediate vacuum chamber disposed between said input vacuum chamber and said analyzer vacuum chamber, said intermediate vacuum chamber comprising an AC-only ion guide for transmitting ions through said intermediate

vacuum chamber, said AC-only ion guide arranged in said intermediate vacuum chamber comprising a plurality of electrodes having apertures, the apertures being aligned so that ions travel through them as they are transmitted by said ion guide;

at least one further differential pumping apertured electrode through which ions may pass, disposed between said vacuum chambers to allow said intermediate vacuum chamber to be maintained at a lower pressure than said input vacuum chamber, and said analyzer vacuum chamber to be maintained at a lower pressure than said intermediate vacuum chamber; and

an alternating current (AC) generator connected to an intermediate chamber reference potential for providing AC potentials to the AC-only ion guide in said intermediate vacuum chamber.

9. A mass spectrometer as claimed in claim 8, wherein:

at least 90% of the apertures of the electrodes forming said AC-only ion guide in said intermediate vacuum chamber are substantially the same size; and

at least 90% of said plurality of the electrodes forming said AC-only ion guide in said intermediate vacuum chamber are connected to the AC generator connected to said intermediate chamber reference potential in such a way that at any instant during an AC cycle of the output of the AC generator, adjacent ones of said electrodes forming said AC-only ion guide arranged in said intermediate vacuum chamber are supplied respectively with approximately equal positive and negative potentials relative to said intermediate chamber reference potential.

10. A mass spectrometer as claimed in claim 8, wherein the AC-only ion guide in said intermediate vacuum chamber comprises at least 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, or 100 electrodes.

11. A mass spectrometer as claimed in claim 8, wherein said intermediate vacuum chamber is arranged to be maintained at a pressure selected from the group consisting of: (i)  $10^{-3}$ - $10^{-2}$  mbar; (ii)  $\geq 2 \times 10^{-3}$  mbar; (iii)  $\geq 5 \times 10^{-3}$  mbar; (iv)  $\leq 10^{-2}$  mbar; (v)  $10^{-3}$ - $5 \times 10^{-3}$  mbar; and (vi)  $5 \times 10^{-3}$ - $10^{-2}$  mbar.

12. A mass spectrometer as claimed in claim 8, wherein electrodes forming said AC-only ion guide in said intermediate vacuum chamber have internal diameters or dimensions selected from the group consisting of: (i)  $\leq 5.0$  mm; (ii)  $\leq 4.5$  mm; (iii)  $\leq 4.0$  mm; (iv)  $\leq 3.5$  mm; (v)  $\leq 3.0$  mm; (vi)  $\leq 2.5$  mm; (vii)  $3.0 \pm 0.5$  mm; (viii)  $\leq 10.0$  mm; (ix)  $\leq 9.0$  mm; (x)  $\leq 8.0$  mm; (xi)  $\leq 7.0$  mm; (xii)  $\leq 6.0$  mm; (xiii)  $5.0 \pm 0.5$  mm; and (xiv) 4-6 mm.

13. A mass spectrometer as claimed in claim 8, wherein the length of said ion guide in said intermediate vacuum chamber is selected from the group consisting of: (i)  $\geq 100$  mm; (ii)  $\geq 120$  mm; (iii)  $\geq 150$  mm; (iv)  $130 \pm 10$  mm; (v) 100-150 mm; (vi)  $\leq 160$  mm; (vii)  $\leq 180$  mm; (viii)  $\leq 200$  mm; (ix) 130-150 mm; (x) 120-180 mm; (xi) 120-140 mm; (xii)  $130 \text{ mm} \pm 5, 10, 15, 20, 25 \text{ or } 30$  mm; (xiii) 50-300 mm; (xiv) 150-300 mm; (xv)  $\geq 50$  mm; (xvi) 50-100 mm; (xvii) 60-90 mm; (xviii)  $\geq 75$  mm; (xix) 50-75 mm; (xx) 75-100 mm; (xxi) 150-200 mm; (xxii)  $\geq 200$  mm; and (xxiii) 50-200 mm.

14. A mass spectrometer as claimed in claim 1, wherein said ion source is an atmospheric pressure ion source.

15. A mass spectrometer as claimed in claim 1, wherein said ion source is a continuous ion source.

16. A mass spectrometer as claimed in claim 1, wherein said ion source is an Electrospray ("ES") ion source or an Atmospheric Pressure Chemical Ionisation ("APCI") ion source.

17. A mass spectrometer as claimed in claim 1, wherein said ion source is an Inductively Coupled Plasma ("ICP") ion source.

18. A mass spectrometer as claimed in claim 1, wherein said ion source is a Matrix Assisted Laser Desorption Ionisation ("MALDI") ion source.

19. A mass spectrometer as claimed in claim 1, wherein said ion mass analyser is selected from the group consisting of: (i) a time-of-flight mass analyser, preferably an orthogonal time of flight mass analyser; (ii) a quadrupole mass analyser; and (iii) a quadrupole ion trap.

20. A method of mass spectrometry, comprising:

producing ions from an ion source;

transmitting at least some of said ions through an input vacuum chamber comprising at least one AC-only ion guide for transmitting said ions, said AC-only ion guide comprising a plurality of electrodes having apertures, said apertures being aligned so that ions travel through them as they are transmitted by said ion guide;

providing AC potentials to said plurality of electrodes from at least one alternating current (AC) generator connected to an input chamber reference potential;

passing said ions to an analyzer vacuum chamber comprising an ion mass analyzer disposed to receive ions after they have been transmitted by said ion guide;

wherein at least one differential pumping apertured electrode is provided through which ions may pass, said at least one differential pumping apertured electrode being disposed between said input vacuum chamber and said analyzer vacuum chamber to permit said analyzer vacuum chamber to be maintained at a lower pressure than said input vacuum chamber; and

wherein at least 90% of said apertures are substantially the same size and at least 90% of said plurality of electrodes forming said AC-only ion guide are connected to said AC generator in such a way that at any instant during an AC cycle of the output of said AC generator, adjacent ones of said electrodes are supplied respectively with approximately equal positive and negative potentials relative to said input chamber reference potential;

said method further comprising the step of: maintaining said input vacuum chamber at a pressure selected from the group consisting of: (i)  $\geq 0.1$  mbar; (ii)  $\geq 0.5$  mbar; (iii)  $\geq 0.7$  mbar; (iv)  $\geq 1.0$  mbar; (v)  $\geq 1.3$  mbar; (vi)  $\geq 1.5$  mbar; (viii)  $\geq 2.0$  mbar; (ix)  $\geq 2.5$  mbar; (x)  $\geq 3.0$  mbar; (xi)  $\geq 3.5$  mbar; (xii)  $\geq 4.0$  mbar; (xiii)  $\geq 4.5$  mbar; (xiv)  $\geq 5.0$  mbar; (xv)  $\geq 6.0$  mbar; (xvi)  $\geq 7.0$  mbar; (xvii)  $\geq 8.0$  mbar; (xviii)

$\geq 9.0$  mbar; (xix)  $\geq 10.0$  mbar; (xx) 1-5 mbar; (xxi) 1-2 mbar; (xxii) 0.5-1.5 mbar; (xxiii)  $\leq 20$  mbar; and (xxiv)  $\leq 30$  mbar.

21. A mass spectrometer as claimed in claim 1, wherein the AC-only ion guide comprises two interleaved comb arrangements, each said comb arrangement comprising a plurality of electrodes having apertures.

22. A mass spectrometer as claimed in claim 1, wherein the AC-only ion guide comprises at least one comb arrangement comprising a longitudinally extending member having a plurality of electrodes having apertures depending therefrom.

23. A mass spectrometer as claimed in claim 22, wherein said input vacuum chamber has a length and said comb arrangement extends at least x% of said length, x% selected from the group consisting of: (i)  $\geq 50\%$ ; (ii)  $\geq 60\%$ ; (iii)  $\geq 70\%$ ; (iv)  $\geq 80\%$ ; (v)  $\geq 90\%$ ; and (vi)  $\geq 95\%$ .

24. A mass spectrometer comprising:

an ion source for producing ions;

an input vacuum chamber comprising at least one AC-only ion guide for transmitting said ions, said AC-only ion guide comprising a plurality of electrodes having apertures, said apertures being aligned so that ions travel through them as they are transmitted by said ion guide;

an analyzer vacuum chamber comprising an ion mass analyzer disposed to receive ions after they have been transmitted by said ion guide;

at least one differential pumping apertured electrode through which ions may pass, said at least one differential pumping apertured electrode being disposed between said input vacuum chamber and said analyzer vacuum chamber to permit said analyzer vacuum chamber to be maintained at a lower pressure than said input vacuum chamber;

wherein:

at least 90% of said apertures are substantially the same size;

at least 90% of said plurality of electrodes forming said AC-only ion guide are connected to an AC generator; and

wherein said input vacuum chamber is arranged to be maintained at a pressure selected from the group consisting of: (i)  $\geq 0.1$  mbar; (ii)  $\geq 0.5$  mbar; (iii)  $\geq 0.7$  mbar; (iv)  $\geq 1.0$  mbar; (v)  $\geq 1.3$  mbar; (vi)  $\geq 1.5$  mbar; (viii)  $\geq 2.0$  mbar; (ix)  $\geq 2.5$  mbar; (x)  $\geq 3.0$  mbar; (xi)  $\geq 3.5$  mbar; (xii)  $\geq 4.0$  mbar; (xiii)  $\geq 4.5$  mbar; (xiv)  $\geq 5.0$  mbar; (xv)  $\geq 6.0$  mbar; (xvi)  $\geq 7.0$  mbar; (xvii)  $\geq 8.0$  mbar; (xviii)  $\geq 9.0$  mbar; (xix)  $\geq 10.0$  mbar; (xx) 1-5 mbar; (xxi) 1-2 mbar; (xxii) 0.5-1.5 mbar; (xxiii)  $\leq 20$  mbar; and (xxiv)  $\leq 30$  mbar.